Outcomes after cardiac arrest in an adult burn center☆,☆☆

CrossMark

Jonathan C. Wilton, Mark O. Hardin, John D. Ritchie, Kevin K. Chung, James K. Aden, Leopoldo C. Cancio, Steven E. Wolf, Christopher E. White *

United States Army Institute of Surgical Research, Fort Sam Houston, TX 78234, United States

ARTICLE INFO

ABSTRACT

Objective: Adult burn patients who experience in-hospital cardiac arrest (CA) and undergo cardiopulmonary resuscitation (CPR) represent a unique patient population. We believe that they tend to be younger and have the added burden of the burn injury compared to other populations. Our objective was to determine the incidence, causes and outcomes following cardiac arrest (CA) and cardio-pulmonary resuscitation (CPR) within this population.

Methods: We conducted a retrospective review at the US Army Institute of Surgical Research (ISR) burn intensive care unit (BICU). Charts from 1st January 2000 through 31st August 2009 were reviewed for study. Data were collected all on adult burn patients who experienced in-hospital CA and CPR either in the BICU or associated burn operating room. Patients undergoing CPR elsewhere in our burn unit were excluded because we could not validate the time of CA since they are not routinely monitored with real-time rhythm strips. The study population included civilian burn patients from the local catchment area and burn casualties from the conflicts in Iraq and Afghanistan, but patients with do-not-resuscitate (DNR) orders were excluded.

Results: We found 57 burn patients who had in-hospital CA and CPR yielding an incidence of one or more in-hospital CA of 34 per 1000 admissions (0.34%). Fourteen of these patients (25%) survived to discharge while 43 (75%) died. The most common initial cardiac rhythm was pulseless electrical activity (50.9%). The most common etiology of CA among burn patients was respiratory failure (49.1%). The most significant variable affecting survival to discharge was duration of CPR ($P < 0.01$) with no patient surviving more than 7 min of CPR.

Conclusions: CPR in burn patients is sometimes effective, and those patients who survive are likely to have good neurological outcomes. However, prolonged CPR times are unlikely to result in return of spontaneous circulation and may be considered futile. Further, those who experience multiple CA are unlikely to survive to discharge.

Published by Elsevier Ltd and ISBI

Report Documentation Page

1. REPORT DATE **07 DEC 2013**	2. REPORT TYPE **N/A**	3. DATES COVERED **-**	
4. TITLE AND SUBTITLE **Outcomes after cardiac arrest in an adult burn center**		5a. CONTRACT NUMBER	
		5b. GRANT NUMBER	
		5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S) **Wilton J. C., Hardin M. O., Ritchie J. D., Chung K. K., Aden J. K., Cancio L. C., Wolf S. E., White C. E.,**		5d. PROJECT NUMBER	
		5e. TASK NUMBER	
		5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **United States Army Institute ofSurgical Research, JBSA Fort Sam Houston, TX**		8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR'S ACRONYM(S)	
		11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT **Approved for public release, distribution unlimited**			
13. SUPPLEMENTARY NOTES			
14. ABSTRACT			
15. SUBJECT TERMS			

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT **UU**	18. NUMBER OF PAGES **6**	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**			

1. Introduction

There is a general consensus that poor outcomes are usually associated with in-hospital cardiac arrest (CA) [1–4] with several studies documenting similar results in various patient populations [4–7]. The largest prospective observational study to date analyzed data from the National Registry of Cardiopulmonary Resuscitation (NRCPR) and concluded that the rate of survival to hospital discharge following pulseless CA was 27% in children and 18% in adults [5]. A separate study examined the epidemiology of in-hospital CA undergoing CPR among a population of 433,985 Medicare patients [6]. This study concluded that the rate of survival to discharge among the elderly with in-hospital CA followed by CPR was 18.3%. In general, knowledge of a patient's long-term prognosis after in-hospital CA with CPR is important to health-care providers as they care for patients and counsel family members. Our objective was to examine the epidemiology of in-hospital CA among adult burn patients receiving CPR or defibrillation at our institution, either in the burn operating room (BOR) or burn intensive care unit (BICU). We included patients who experienced CA in the BOR because these patients were continuously monitored in a similar fashion as the BICU, and here, CA would be recognized and treated immediately. We commenced this study with two specific hypotheses: first, we hypothesized that respiratory dysfunction is the most common etiology of in-hospital CA among burn patients, and second, that patients who survive in-hospital CA with CPR had shorter CPR times than non survivors.

2. Methods

We performed a retrospective review of all adult burn patients admitted to the United States Army Institute of Surgical Research (USAISR) BICU or who were treated in the BOR. Both civilian and military patients were included. Subjects were excluded from the study if they had standing do not resuscitate (DNR) orders, were less than 18 years old or were pregnant. Charts were reviewed for the period starting in January 2000 through August 2009. Demographic data gathered for each of the patients in the study included age, gender and status (military or civilian). Injuries were characterized by the date they occurred, mechanism of injury, injury severity score (ISS), the presence or absence of inhalation injury and the total body surface area (TBSA) burned. All subjects with a probable history of inhalation injury were screened by bronchoscopy upon admission to the BICU. Those identified as having an inhalation injury showed evidence of airway damage consistent with inhalation injury such as soot, edema or erythema. TBSA was determined using the Lund and Browder chart and was recorded by the attending physician. For the purpose of the study, CA was defined as the loss of spontaneous circulation and the initiation of CPR as documented in the patient's chart. Successful CPR was defined as the return of spontaneous circulation (ROSC). To characterize the CA, we recorded the first documented rhythm at the time of arrest, duration of CPR, administration of advanced cardiac life support (ACLS) medications and performance of adjunctive procedures (such as advanced or surgical airways, bronchoscopy or tube thoracostomy). The etiology of the CA was characterized as cardiac or respiratory, in accordance with the determination made by the in-hospital physician present during the resuscitation and documented in the patient's chart. The outcome of the resuscitation was recorded as ROSC or death. Patients were identified as long-term survivors if they survived to hospital discharge. Collected data were entered into a spreadsheet (Microsoft Excel 2003) and analyzed using SPSS (Statistical Package for the Social Sciences) version 16.0 (SPSS Inc., Chicago, IL). Categorical variables were compared with a chi-square test and continuous variables were compared using the Student's t-test for normal distributions or the Mann–Whitney U test for nonparametric distributions. Statistical significance was defined by $p < 0.05$.

3. Results

Over the course of the study, we assessed 1691 admissions to the BICU and/or BOR with 57 patients experiencing 72 in-hospitals CAs. These 57 subjects constituted the population in this study (Fig. 1). The incidence of one or more CAs in this population was 34 per 1000. The median age of those studied was 37 years [interquartile range (IQR): 27–50 years]. Eighty-eight percent of the patients were men. Sixty-seven percent had a documented inhalation injury. The median TBSA was 44% (IQR 25%–62%). Twelve of the 57 subjects (21%) experienced multiple CAs. None of the patients with multiple CAs survived to discharge. Fourteen of the 57 patients survived to hospital discharge corresponding to a 25% rate of survival to discharge among burn subjects experiencing in-hospital CA at our institution. Eight of these 57 arrested in the BOR, and these subjects had an overall survival rate of 50%. All of those who died succumbed to their illness within 24 h of CA (Fig. 2).

Among the subjects in this study, 75% had a ROSC. However, this did not translate into long-term survival in most cases as the majority of subjects who had ROSC following CA and CPR ultimately died in-house. Of the 14 patients who survived to discharge, all but one had a meaningful neurologic recovery with a Glasgow coma scale (GCS) at discharge of 15. Only one of the 14 survivors was diagnosed with anoxic brain injury (discharge GCS 6), which was the result of failed intubation/delayed cricothyroidotomy with resulting anoxia.
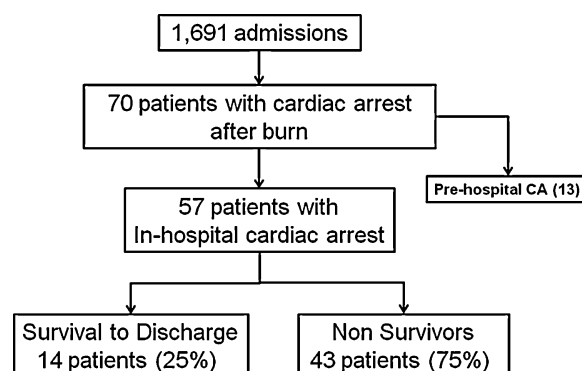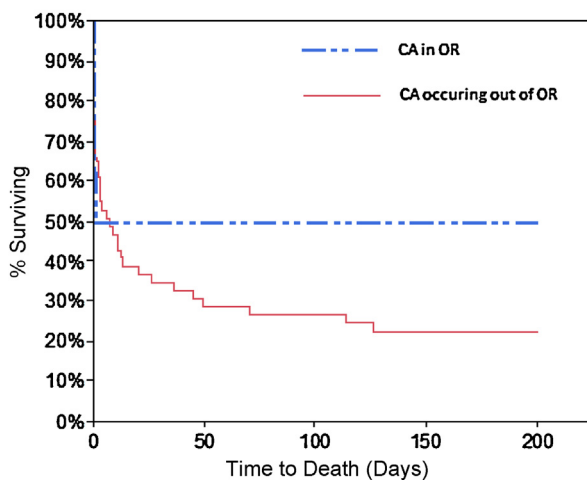

Fig. 1 – Consort diagram.

Fig. 2 – Survival of CA subjects in operating room versus burn intensive care unit.

The most common initial rhythm in our population of CA patients was pulseless electrical activity (PEA) (50.9%), followed by asystole (38.6%), ventricular tachycardia (5.3%), ventricular fibrillation (3.5%) and unknown (1.8%). The most common etiology of CA was respiratory (49.1%) followed by cardiac (28.1%) and unknown (22.8%). Duration of CPR was significantly shorter for survivors than non survivors. Median duration of survivors was 1 min (IQR: 1–4 min). Median duration of CPR in non-survivors was 6 min (IQR: 2–22 min). No patient received CPR for longer than 7 min and survived to discharge. Fig. 3 shows a Kaplan–Meier analysis of times to death in non-survivors. There was no difference in outcomes, either ROSC or survival to discharge, when comparing etiology of CA (Table 1). On both univariate analysis (Table 2) and multivariate logistic regression (Table 3), we found no significant difference between survivors and non survivors with respect to age, percentage of TBSA or incidence of inhalation injury.
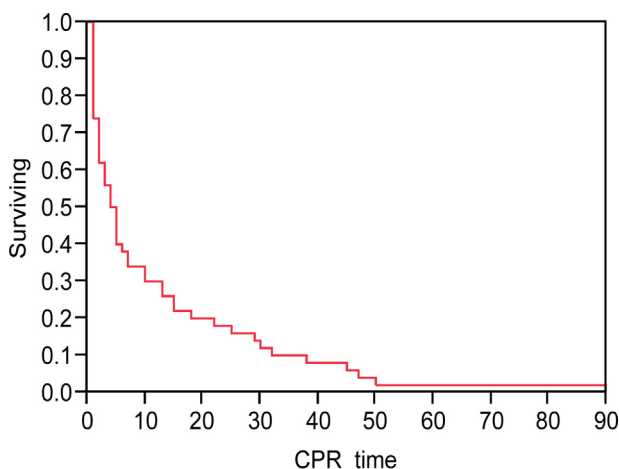
Fig. 3 – Kaplan–Meier analysis of times to death in non-survivors.

Table 1 – Comparison of outcomes by etiology of cardiac arrest.

Outcome	Respiratory	Cardiovascular	p value
Return of spontaneous circulation (%)	70	73	0.86
Survival to discharge (%)	30	19	0.49

The use of advanced cardiac life support (ACLS) medications in this population was associated with longer CPR time and lower rates of ROSC. The average CPR time when either bicarbonate and/or calcium and/or vasopressin was administered during resuscitation was 23 min compared to 3 min when no ACLS drugs were used with a return to ROSC of 45% versus 97%, respectively ($p < 0.01$). The exception to this was the use of atropine during code events. Here, atropine tended to be used alone, in contrast to the other named drugs above, which were more often used in combination. CPR times remained longer on average with atropine than when no ACLS drug was used (7 versus 3 min). ROSC was achieved 72% of the time with atropine compared to 44% when other ACLS drugs were used, but this did not reach significance ($p = .30$).

The use of Advanced Trauma Life Support (ATLS) adjuncts to ACLS was not associated with improved outcomes. There were no survivors in this study among the 13 patients who underwent tube thoracostomy with median CPR times in these patients being 39 min (IQR: 16–46 min). The one patient who had an emergent airway performed had a poor neurological outcome as documented above. All subjects who underwent exploratory laparotomy for suspected abdominal compartment syndrome died in the BICU.

4. Discussion

The incidence of one or more in-hospital CAs receiving CPR at our institution was 34 per 1000 admissions with an overall rate of survival to discharge among these patients of 25%. The survival rate at our institution is within the range reported in related studies [1,2,6–10]. A 2003 CPR study utilizing the NRCPR reported 17% survival to discharge among 14,720 patients with in-hospital CA and CPR [7] and in a 2009 study of Medicare beneficiaries 65 years of age or older, 18.3% of the 433,985 patients who underwent in-hospital CPR survived to hospital

Table 2 – Univariate analysis of survivors versus non survivors.

Variable	Survivors (n = 14)	Non survivors (n = 43)	p value
Age (yr)	26 (22–37)	40 (24–54)	0.112
Total burn surface area (%)	34 (21–49)	51 (28–65)	0.097
Inhalation injury (%)	64	65	0.79
Cardiopulmonary resuscitation time (min)	1 (1–4)	6 (2–22)	0.001[a]

[a] Median (25th–75th) percentiles.

Table 3 – Multivariate logistic regression.		
Variable	Odds ratio	95% Confidence Interval
Age (yr)	1.1	1.0–1.2
Total burn surface area (%)	1.0	1.0–1.1
Cardiopulmonary resuscitation time (min)	2.8	1.4–5.8
[a] Model includes all variables with $p < 0.2$.		

discharge [6]. More specific to our population, a study conducted at the Shriner's Burn Hospital in Galveston, which included 34 children with greater than 35% TBSA burns who underwent in-hospital CA and CPR reported a 50% rate of survival to discharge [8].

The potential determinants of outcomes of in-hospital CA followed by CPR are numerous, varied, and – in some instances – controversial [2,3,6]. Different studies of in-hospital CA are likely to report widely varying survival rates as a result of study populations with characteristic but distinct demographics and medical histories [4]. In addition to differences in study populations, a lack of uniformity in study design and reporting can make comparisons between studies difficult [4,5,7,9,10]. The median age of subjects in our study was 37 years, with 30% of this population being military wounded from operations in Iraq and Afghanistan. These tend to be younger than the civilian population at large and as such are likely to have fewer co-morbidities than the subjects in the registry studies mentioned above. Another reason the overall survival rate in our study may be higher is that eight of the 57 subjects (14%) experienced CA in the BOR. Of these cases, half occurred during induction of anesthesia while three were due to hypoxia; only one of the eight subjects experienced hypotension as a cause of his CA. Four of these patients (50%) survived to discharge. We hypothesize that the disparity in survivors between locations (BOR versus BICU) is the result of prompt intervention by the anethesiologist to identify the CA and then direct the BOR team to administer CPR while working rapidly to correct the underlying cause of CA. If we exclude the eight patients who arrested in the BOR, the overall rate of survival to discharge drops from 25% (14 out of 57) to 20% (10 out of 49) which is essentially the same as other large studies involving in-hospital CA in adult patient populations [1–4,6,7].

Fig. 2 shows the distribution of deaths among the eight patients who initially arrested BOR and were transferred to the BICU versus the 49 patients who initially arrested in the BICU. Those whose CA began in the BOR and survived to discharge had a good neurological outcome. The non survivors in this group died within 24 h. The survival curve for patients who experienced CA outside the BOR indicates that the majority of patients who did not survive died over a relatively longer period (range of 0–124 days). Although a small percentage of this study population, those who arrest in the BOR and survive the first 24 h have a good prognosis and represent a distinct subgroup for the reasons listed above. We hypothesize that the inclusion of relatively manageable, iatrogenic CA accounts in part for the higher rate of survival in this cohort. In fact, this represents a different patient population from those who experience CA in other locations in the hospital.

Another factor that can affect the outcome of patients who experience CA is the use of DNR orders [2–4,10]. Our data demonstrate that approximately 20% of adult patients undergoing CPR without previous DNR orders survive to discharge with normal neurologic function. Based upon our analysis, we could find no reliable clinical predictors of outcome prior to the CPR event; thus, we conclude that reasonable measures including CPR should be undertaken in the event of CA in burned adults. However, from our experience, there were no survivors to discharge beyond 7 min of CPR or in those experiencing multiple episodes of CA. In these cases, it should be recognized that the likelihood of ROSC and meaningful neurological recovery rapidly diminishes as CPR time increases, and along these lines, consideration may be given to limiting the length of time of providing CPR due to futility of effort while at the same time attempting to protect health care providers from harm as a result of exposure of blood/blood products or bodily fluids during CPR.

After CA and CPR when spontaneous circulation is restored, it may then be appropriate to discuss DNR orders with the patient or her/his family to limit further futile attempts. We recommend that an institution's DNR policy and subsequent counseling include assessment of the patient's and/or family's wishes in relation to her/his age, co-morbidities and burn size and chance of meaningful recovery with particular attention given to the length of initial code or the fact that the patient has had multiple code events. A strict DNR policy would deprive some potential survivors (or 1 in 5 in this study) of the opportunity for further treatment and discharge from the hospital since presently we have no way to accurately predict those who would have a good neurological outcome following CA event(s).

In our study, the most common initial rhythms encountered were PEA (50.9%) and asystole (38.6%), whereas the most common etiology of CA was respiratory (49.1%). In comparison, the NRCPR study reported a predominance of PEA or asystole as the initial rhythm in in-hospital CA [7] and listed three common causes of CA in adults as (1) cardiac arrhythmia; (2) acute respiratory insufficiency and; (3) hypotension [5,7]. With respect to initial cardiac rhythm and etiology, burn patients with CA are not unlike patients among the general population with CA.

Our study showed that long CPR times were not consistent with survival. In fact, the longest CPR time in a survivor was 7 min, which was complicated by subsequent anoxic neurological insult (see below). Multivariate logistic regression with CPR as a binary variable (CPR time < 3 min or CPR time - ≥ 3 min) demonstrated a risk of death five times greater when CPR extended beyond 3 min. Specifically, CPR time ≥ 3 min was associated with an odds ratio of death of 5.5 (95% confidence interval: 1.1–26.2). There were no survivors among burn patients who had more than one CA.

After CA and resuscitation, neurological outcomes in our study were consistent with those in other studies [2,5,7–9]. Among the 14 patients who survived to discharge, all but one had a meaningful neurologic recovery. Thirteen of the 14 patients had a discharge GCS of 15. Only one patient had diagnosed anoxic brain injury and a discharge GCS of 6. This patient had a failed intubation, prolonged hypoxia and a

subsequent cricothyroidotomy during the CA. Indications are that this patient's poor neurological outcome was a result of anoxia secondary to respiratory failure. This supports the conclusion that in the absence of other pathology, patients who survive their initial CA arrest are likely to have a good neurological outcome. Similar results regarding neurological outcomes were identified in other studies of in-hospital CA [2,5,7–9]. This may raise the question of whether some of these patients were, in fact, in CA and required CPR; however, since our results are similar to others', this may show an implicit weakness in study design regarding CA and CPR.

In an attempt to identify factors that affect a subject's outcome, we examined the impact of various parameters on the likelihood of a patient's death. Among the variables collected in this study, CPR time was found to be the strongest predictive factor associated with death. A second factor, age, was found to have a small impact on survival (odds ratio 1.09; 95% confidence interval 1.0–1.2). This is consistent with other studies which found that age was not significantly associated with a patient's outcome following in-hospital CA and CPR [4,10]. Likewise, neither TBSA and presence of inhalation injury were useful determinants in predicting patient outcomes. The use of ACLS medications and ATLS adjuncts do not increase the likelihood of survival after CA, and may act as surrogates for increased CPR time. As mentioned above, these data need to be presented in the context of the patient's wishes, overall health and length and number of times s/he has had a CA and underwent CPR when discussing DNR orders with patients and/or family members.

This study is a retrospective chart review and was restricted to adult burn patients who underwent CA and CPR at USAISR, and as such, has all the inherit limitations of this study design. In other studies, the time between CA and defibrillation and, in children, the time between burn and fluid resuscitation have been shown to be important factors in survival in CA [7,8]; however, neither interval was determined in the present study. Further, studies have shown that sepsis is a significant factor for poor prognosis after CA [2,10]; however, this variable was not captured in our data set. Our study included combat casualties suffering burn wounds, and this may limit its comparison with a civilian population. Last, the ACLS protocols were revised during the course of this study [11]; however, it is unlikely that these changes subsequently affected measured variables since, in a BICU or BOR setting, CA would almost always be recognized quickly, and multiple, trained health care professionals would be available to establish a patent airway and provide ventilation and precordial compressions while continuously assessing the efficacy of these interventions with available monitors (i.e. arterial blood pressure, end tidal CO_2, etc.).

5. Conclusion

Compared to other populations with in-hospital CA and CPR, the burn population has similar causes and outcomes. CPR after CA among burn patients is not futile and should be initiated in the BICU or the BOR when a patient if found to be in CA. In fact CA, in the burn OR or peri-operative period, is primarily survivable given immediate recognition and treatment of inciting cause(s). Prolonged CPR times and/or multiple CA followed by CPR, however, are unlikely to yield meaningful survivors. Other factors such as etiology (whether respiratory or cardiac in origin), TBSA and inhalation injury had no impact on survival and cannot be used to predict outcomes before CA, or after the fact in cases of CA arrest with CPR followed by ROSC. Further, resuscitations that require the use of ACLS medications or adjuncts such as tube thoracostomy or laparotomy, all of which point to longer CPR time, are unlikely to result in survival to discharge.

Disclaimer

Conflict of interest

None declared.

Acknowledgements

REFERENCES

[1] Curtis L, Parshley P, Kemalyan N. Cardiopulmonary arrest: incidence and outcome in the burn population. J Burn Care Rehabil 1997;18:S119.

[2] Sandroni C, Nolan J. In-hospital cardiac arrest: incidence, prognosis and possible measures to improve survival. Intens Care Med 2007;33:237–45.

[3] Weil MH, Fries M. In-hospital cardiac arrest. Crit Care Med 2005;33(12):2825–30.

[4] Brindley PG, Markland DM, Mayers I, Kutsogiannis DJ. Predictors of survival following in-hospital adult cardiopulmonary resuscitation. CMAJ 2002;167(4): 343–8.

[5] Nadkarni VM, Larkin GL, Peberdy MA, Carey SM, Kaye W, Mancini ME, et al. First documented rhythm and clinical outcome from in-hospital cardiac arrest among children and adults. JAMA 2006;295(1):50–7.

[6] Ehlenbach WJ, Barnato AE, Curtis JR. Epidemiologic study of in-hospital cardiopulmonary resuscitation in the elderly. N Engl J Med 2009;361:22–31.

[7] Peberdy MA, Kaye W, Ornato JP, Larkin GL, Nadkarni V, Mancini ME, et al. Cardiopulmonary resuscitation of adults in the hospital: a report of 14,720 cardiac arrests from the national registry of cardiopulmonary resuscitation. Resuscitation 2003;58:297–308.

[8] Jeschke MG, Herndon DN. Long-term outcomes of burned children after in-hospital cardiac arrest. Crit Care Med 2000;28(2):517–20.

[9] Reis AG, Nadkarni V, Perondi MB, Grisi S, Berg RA. A prospective investigation into the epidemiology of in-hospital pediatric cardiopulmonary resuscitation using the Utstein reporting style. Pediatrics 2002;109(2):200–9.

[10] Ballew KA, Philbrick JT, Caven DE, Schorling JB. Predictors of survival following in-hospital cardiopulmonary resuscitation: a moving target. Arch Intern Med 1994;154:2426–32.

[11] American Heart Association Guidelines. Circulation 2005;112:IV1–5.